Lawrence Livermore National Laboratory

Physical Sciences

Introduction – Definition of the Basic Questions for this FUSHE2012 Workshop

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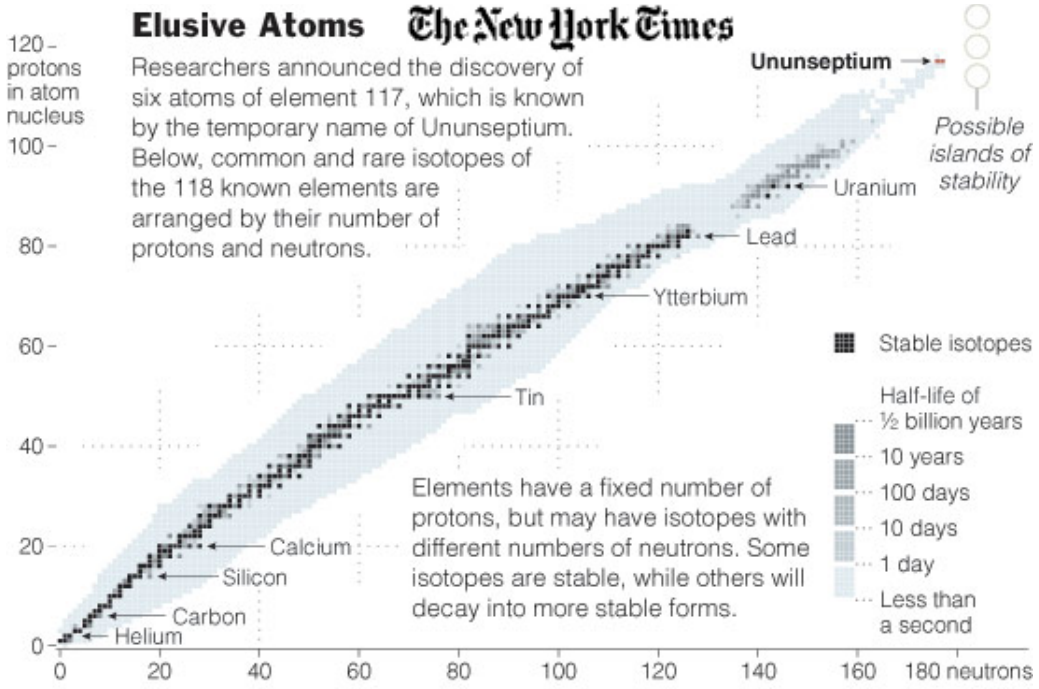
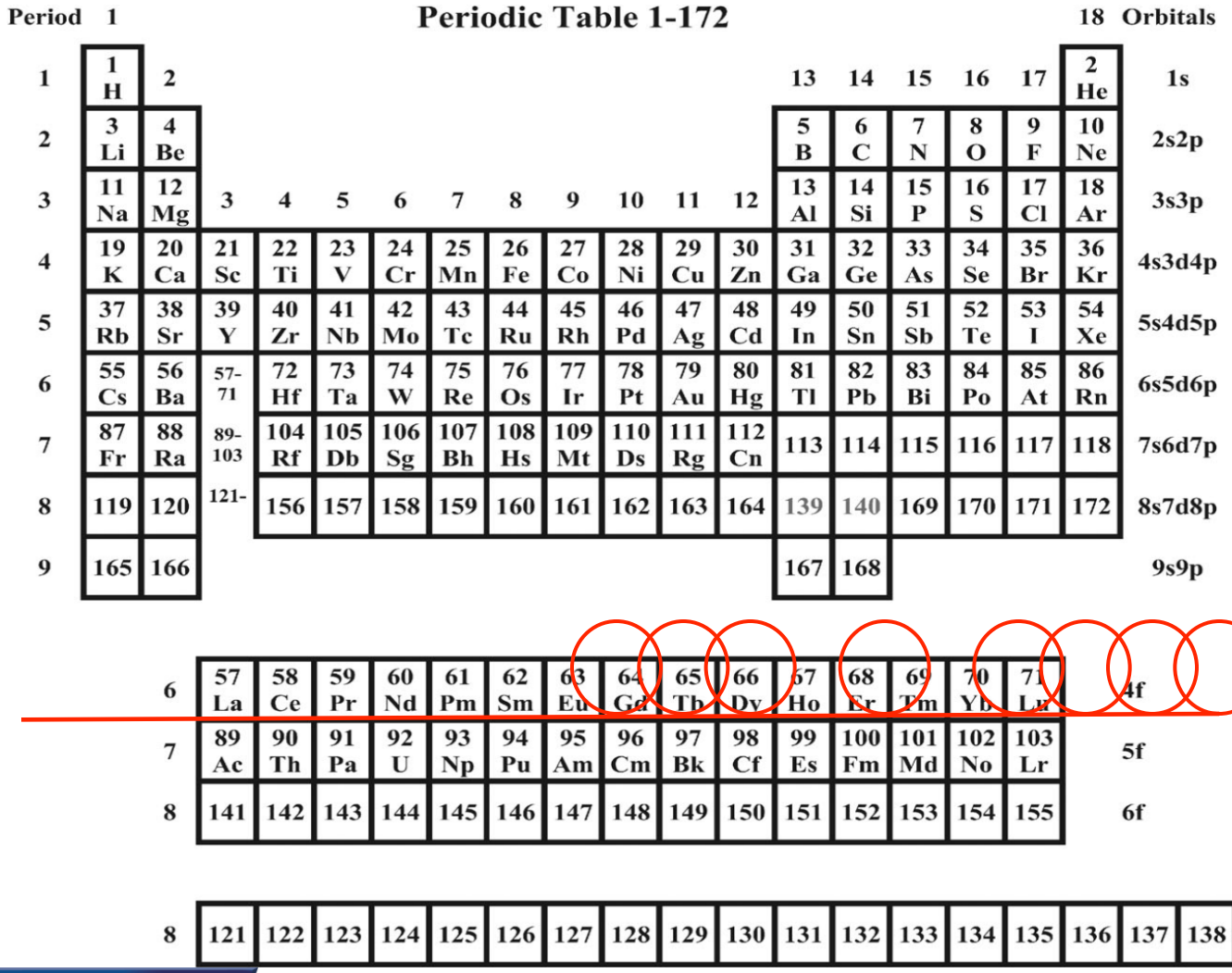
Discovery of a new element is as fascinating to the public as landing on the moon (or Mars)

"The question we're trying to answer is, 'Does the periodic table come to an end, and if so, where does it end?' "
Kenton Moody -- LLNL



The chemistry of an element, and its adherence or lack thereof to periodicity, is a fundamental scientific question



Elements for which no chemical info known

Elements don't have to fit into the periodic table in this way!

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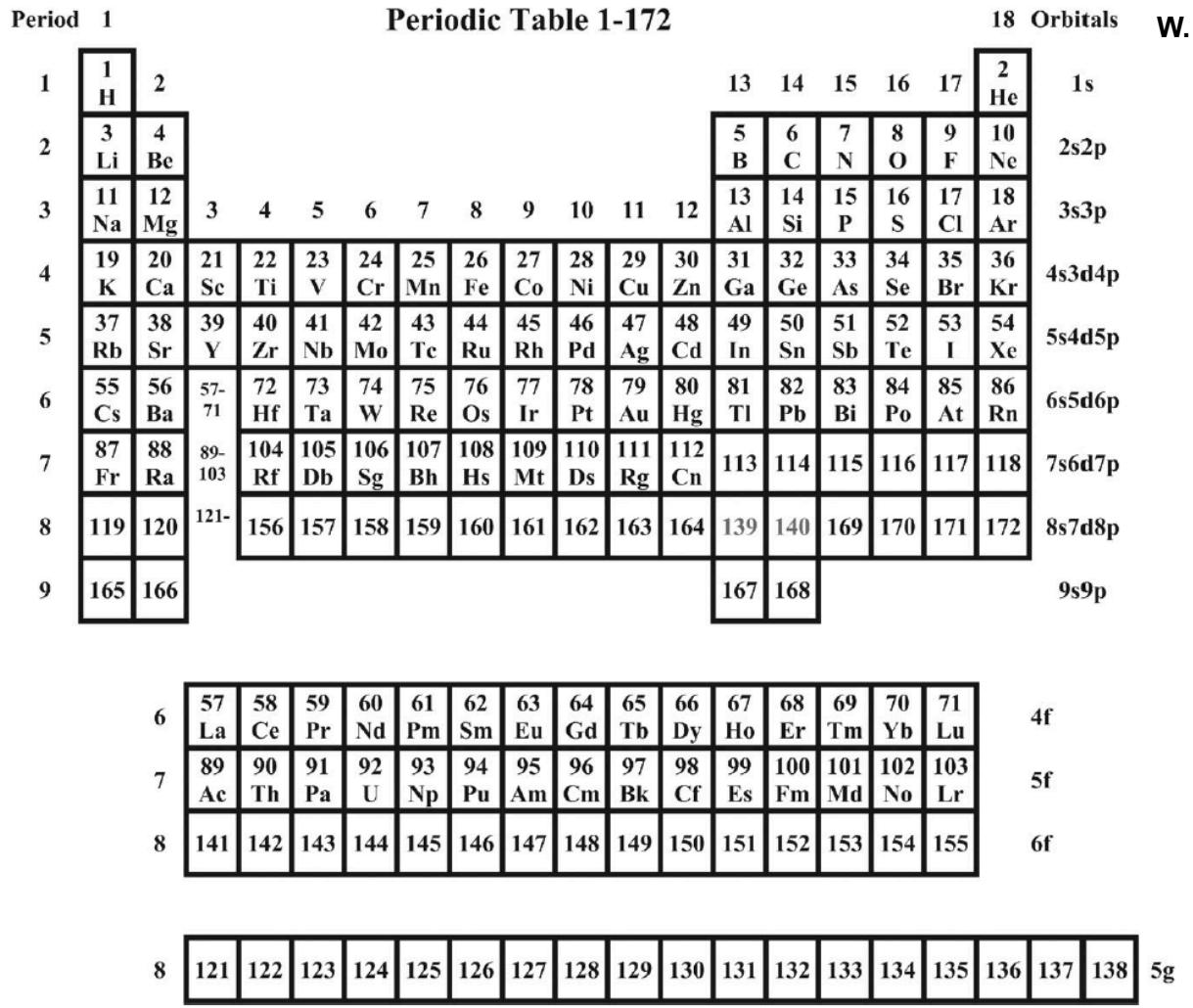
P. Pyykkö, Phys. Chem. Chem. Phys. **13**, 161 (2011)

How many more elements are there?

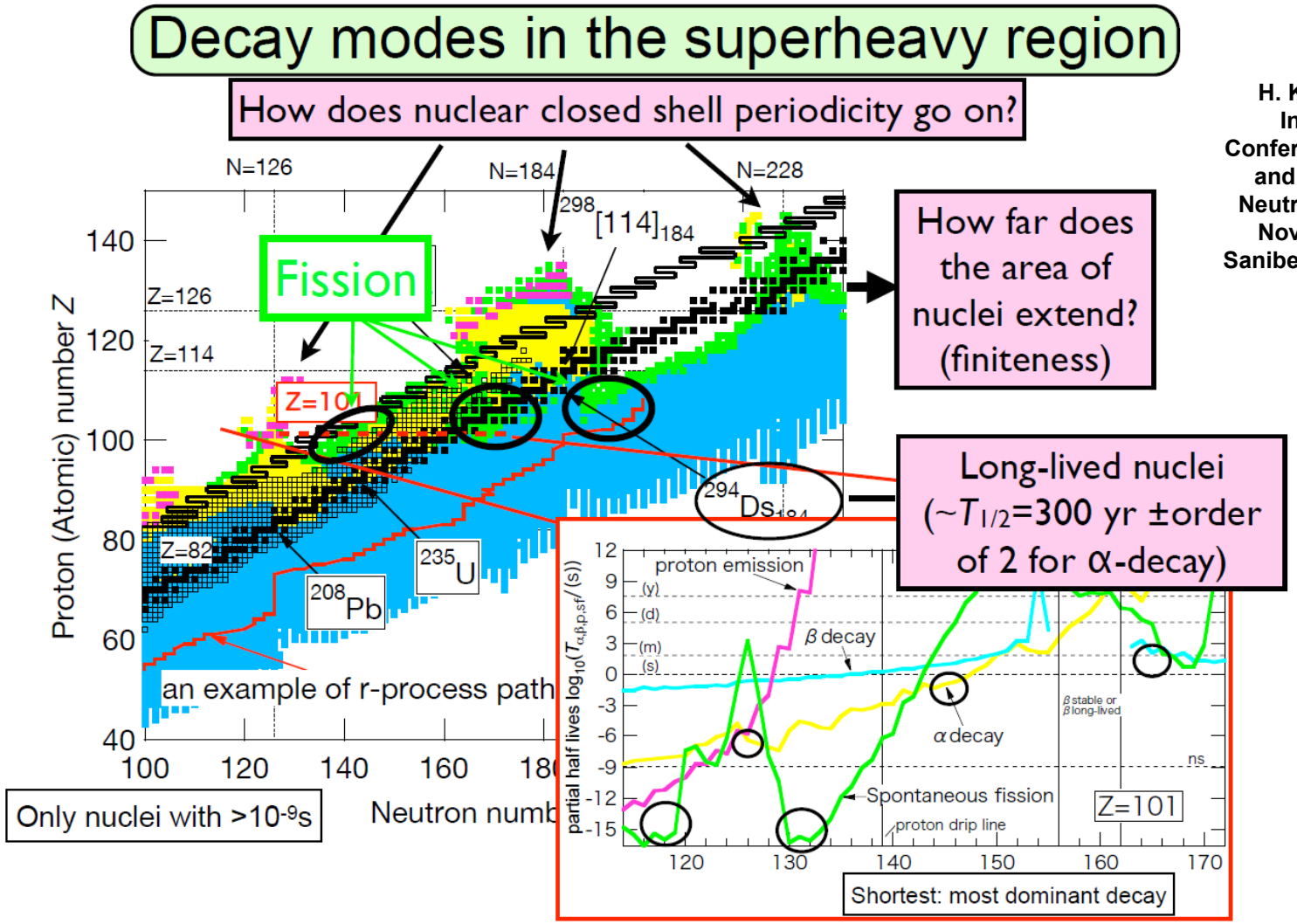


W. Nazarewicz APS April Meeting 2012, Atlanta, GA

"Half of chemistry is still undiscovered. We don't know what it looks like and that's the challenge"

The limit of mass and charge is still undiscovered. We don't know what it looks like and that's the challenge.

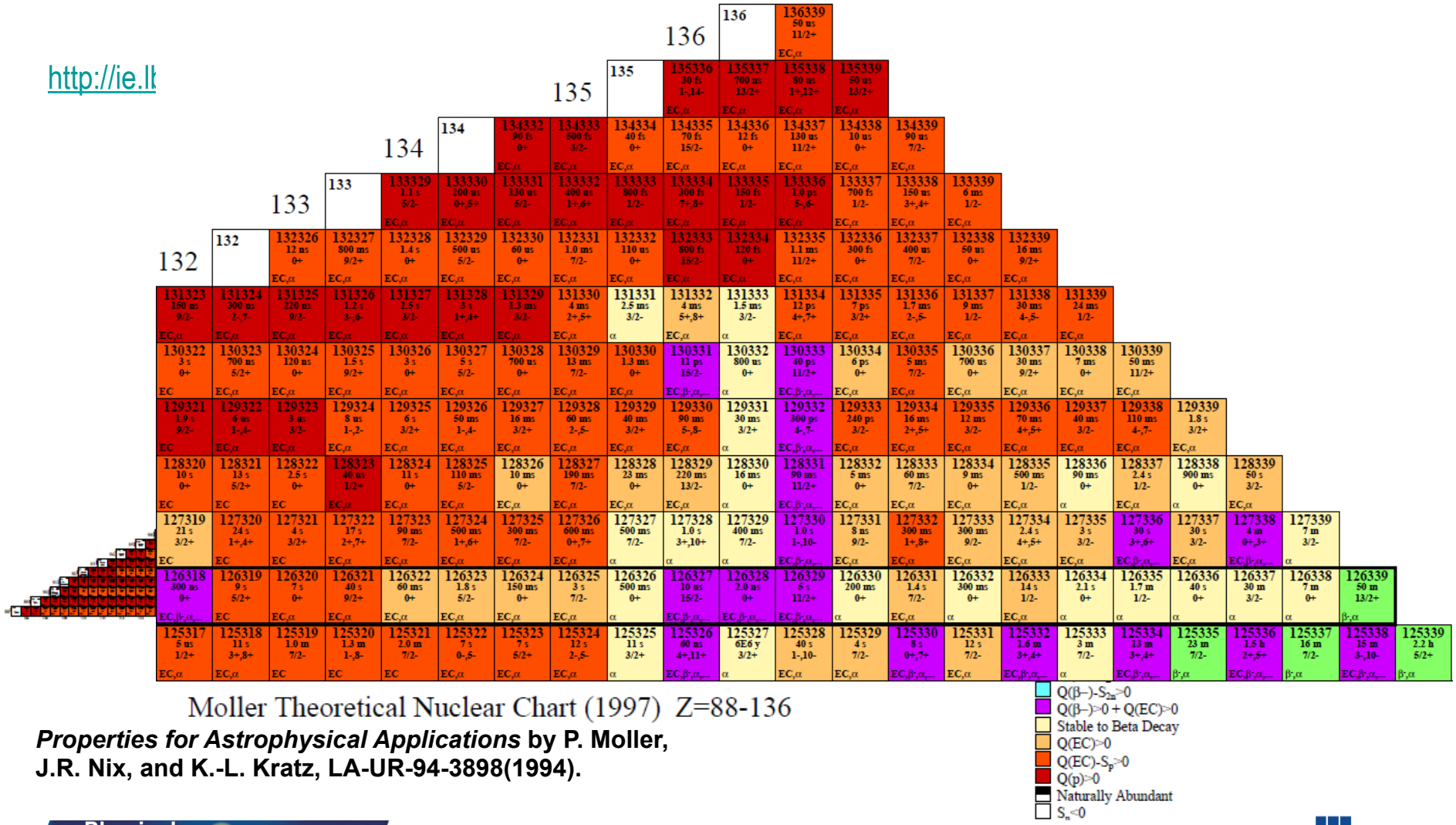
Just exactly where are the next closed shells and how many nucleons can be bound together in a nucleus?



H. Koura, Fourth International Conference on Fission and Properties of Neutron-Rich Nuclei Nov. 11-17, 2007, Sanibel Island, FL, USA

Another version of decay properties predicted for heavy isotopes

http://ie.lt



Properties for Astrophysical Applications **by P. Moller, J.R. Nix, and K.-L. Kratz, LA-UR-94-3898(1994).**

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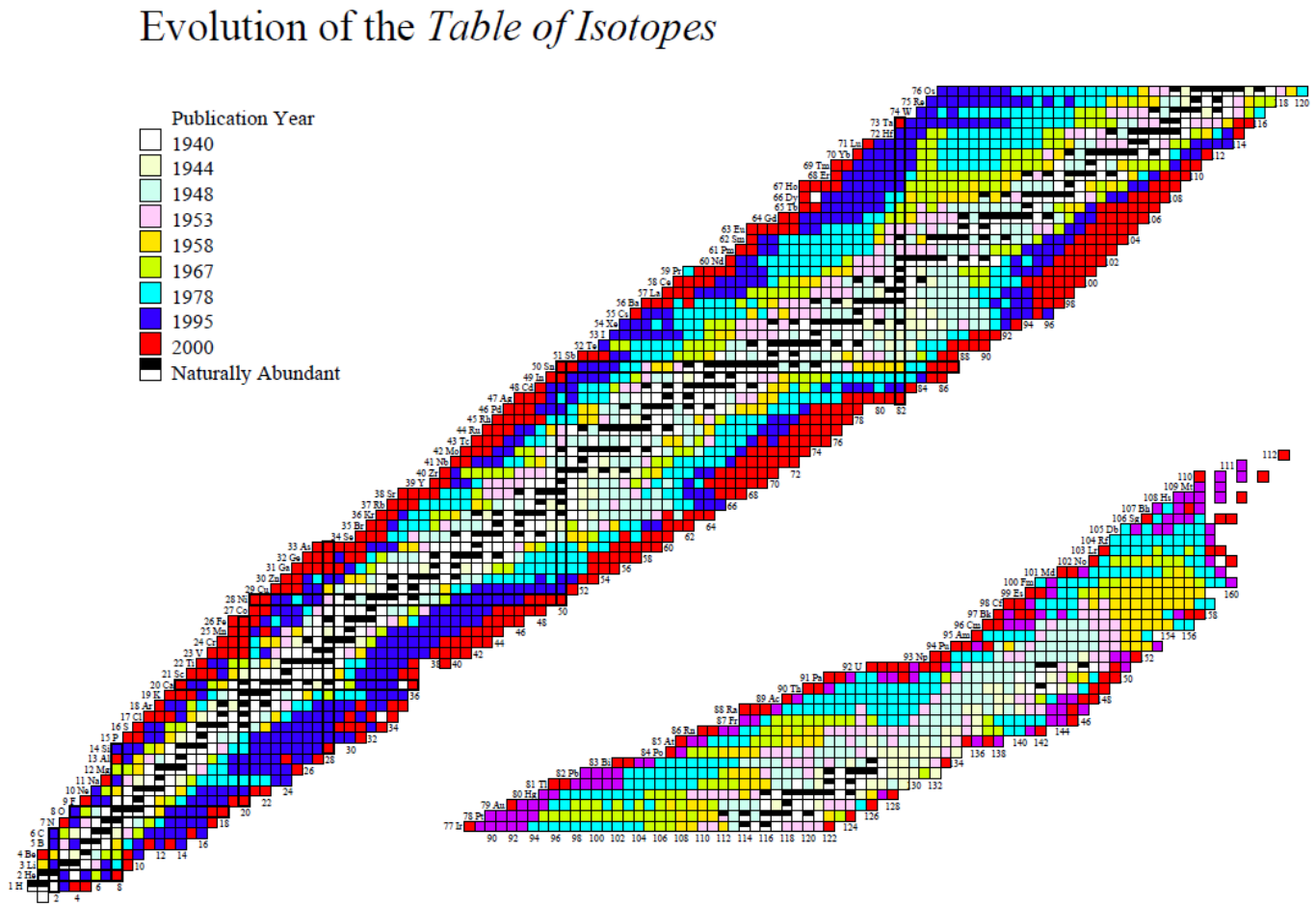
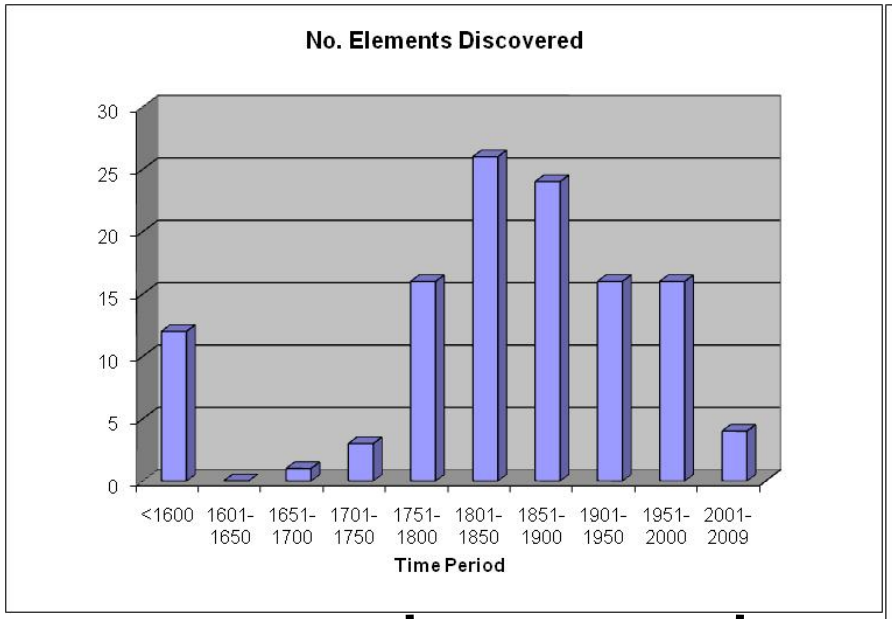
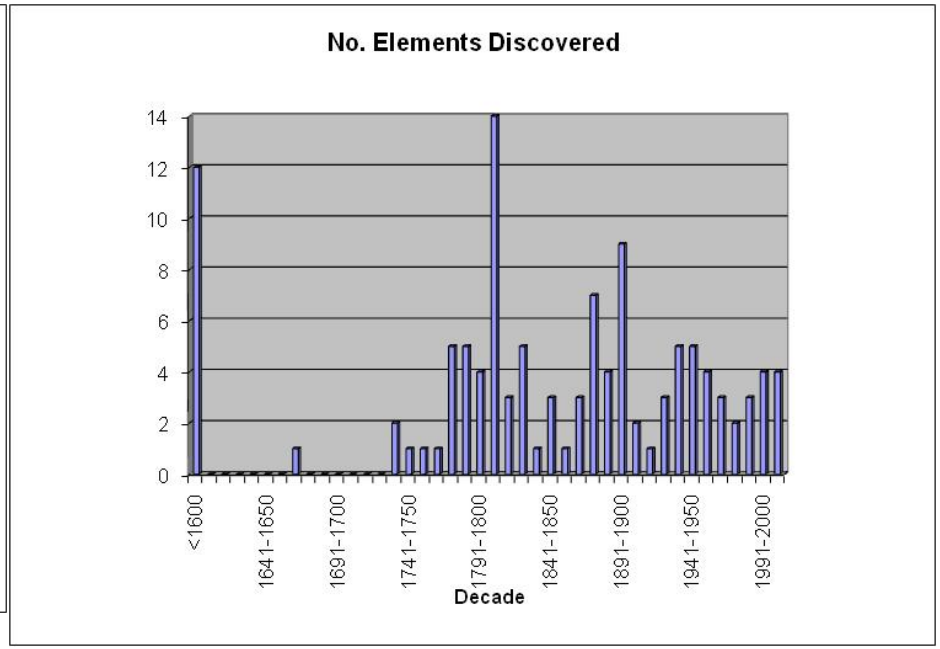
History of the discovery of isotopes

http://ie.lbl.gov/systematics/history00.pdf



New element discovery has progressed steadily since the 1700's





On average, just under 20 elements have been discovered every half-century

On average, about 4 elements have been discovered every decade

FUSHE 2012 - Topics and Goal

- Experiment
- Theory
- Instrumentation

Goal:

Discuss and define the (near and far) future strategy for the field of SHE research

Experiment

- **Z- and A identification of the isotopes produced in ^{48}Ca-induced reactions on actinide targets**
- **Single particle trends towards the gap of the spherical SHE**
- **Ground state properties (e.g. masses)**
- **Decay properties (fission barriers, lifetimes) of SHE**
- **Chemical properties**
- **Reaction mechanism**
- **Collective properties/in beam spectroscopy**

FUSHE 2012 - Topics

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Goal:

Discuss and define the (near and far) future strategy for the field of SHE research

Theory

- **Spherical and deformed shell gaps, density profiles, stabilization mechanisms (shell, vibrational etc.).**
- **Structure of ground and low-lying excited states of SHN: energies, spins, parities, transition strengths, isomerism**
- **Evolution of ground state shapes and fission barriers as function of Z and A, and limits of the region of SHE**
- **Excitation energy dependence of fission barriers**
- **Evolution of di-nuclear systems: contact to capture, fusion-fission, deep-inelastic collision etc.**
- **Energy transfer, dissipation-fluctuation dynamics in nuclear reactions.**
- **A review of the relevant models and guidance for future experiments.**
- **SHE quantum chemistry**
- **Astrophysical relevance for SHE**

FUSHE 2012 - Topics

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Goal:

Discuss and define the (near and far) future strategy for the field of SHE research

Instrumentation

- **High intensity stable beam accelerator**
- **High current/low energy target development**
- **New separators (S3, M/Q- or other mass selection/spectroscopy)**
- **Detector development**
- **Inbeam spectroscopy/target (gammas, electrons,...)**
- **Decay spectroscopy/after separation (ERs, alphas, gammas, electrons, X-rays)**
- **Electronics (digital, pulse shape analysis,...)**
- **Ion traps**
- **Laser spectroscopy**
- **Chemistry instrumentation (gas-jet transport system; ion-exchange, solvent extraction, electro-chemistry apparatuses; gas-chemistry apparatuses; chemistry apparatus coupled to recoil separators, detectors coupled to chemistry apparatus)**

FUSHE 2012 - Session Organisation

Sessions

- The **three main categories** will be combined under various topics such as nuclear structure or synthesis, which will be wrapped up in a final discussion for each **"theme"**.
- The "themes" should, where possible, consist of contributions from the three main categories.
- The sessions will be guided by **discussion leaders** who will **extract strategic ideas, milestones** etc.
- The outcome of the various sessions will be put together in **a final strategy paper** representing the basis for the **common strategy of the SHE community** brought together in the workshop.

The workshop is organized into sessions that cut across experiment, theory and instrumentation

- Monday morning – SHE synthesis
- Monday afternoon, continuing to Tuesday morning– heavy and SHE nuclear structure
- Tuesday afternoon – chemistry of the heaviest elements
- Wednesday morning – SHE unified and novel aspects
- Wednesday afternoon – final discussions with conclusions

FUSHE 2012 - Venue



The *Conference&Sports Hotel Erbismühle* is located in a nice valley, the *Weiltal*, in the *Taunus hills* about 50 km north of Frankfurt (50 km to Frankfurt main station and 55 km to Frankfurt airport) close to the *village Weilrod* in the centre of Germany.

The *Taunus hills* have formed the northern border of the Roman Empire and traces of it can still be visited today like the rebuilt Roman Castle *Saalburg* together with a few meters of the *limes*, the Roman border installations and defence line against the barbarians north of it…

FUSHE 2012 - Organising Committee

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Ch. Stodel (scientific secretary – GANIL)
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M. Block (GSI)
P. Greenlees (JYFL)
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A. Wieloch	U. Cracow, Poland
A. Yakuschev	GSI, Darmstadt, Germany
V. Zagrebaev	JINR-FLNR, Dubna, Russia

France	6
Germany	4
Japan	3
Finland	2
Poland	2
U.S.A.	2
Belgium	1
Russia	1
U.K.	1
Switzerland	1
Total	23

Experiment	*14*
Theory	*9*

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V. Zagrebaev	JINR-FLNR, Dubna, Russia

France	***6***
Germany	***4***
Japan	***3***
Finland	***2***
Poland	***2***
U.S.A	***4***
Belgium	***1***
Russia	***2***
U.K.	***1***
Switzerland	***1***
Total	***26***
Experiment	***17***
Theory	***9***

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We will discuss many ideas for near and long term future developments in SHE, but I would urge "thinking big" also

- Surely, we will talk about incremental improvements in targets, accelerators, detection, etc., but what about an international accelerator dedicated to SHE synthesis and research?
- Surely, we will talk about improvements in theory, but what about a dedicated super-computer for SHE calculations?

Challenge: Make one suggestion for long term future (10-20 years)

Unfortunately, we are one less person to make and execute this “Future of SHEs” plan

John Wild (1942-2012)

Memorial service planned for June 24, 2012